

United States Patent [19]  
Matsui

US005444305A  
[11] Patent Number: 5,444,305  
[45] Date of Patent: Aug. 22, 1995

60245 U.S. PTO  
08/916280

08/22/97

[54] SEMICONDUCTOR MEMORY CIRCUIT

[75] Inventor: Yoshinori Matsui, Tokyo, Japan

[73] Assignee: NEC Corporation, Tokyo, Japan

[21] Appl. No.: 84,017

[22] Filed: Jun. 30, 1993

[30] Foreign Application Priority Data

Jun. 30, 1992 [JP] Japan 4-172229

[51] Int. Cl. 6 G11C 7/00

[52] U.S. Cl. 365/207; 365/189.01;  
365/221; 365/230.03; 365/230.04

[58] Field of Search 365/189.01, 230.03,  
365/221, 207, 230.04, 196

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Primary Examiner—Joseph A. Popek

Assistant Examiner—Huan Hoang

Attorney, Agent, or Firm—Sughrue, Mion, Zinn,  
Macpeak & Seas

**SEMICONDUCTOR MEMORY CIRCUIT****BACKGROUND OF THE INVENTION****1. Field of the Invention**

This invention relates to a semiconductor memory circuit, and more particularly to a semiconductor memory circuit which includes shared sense amplifiers and is adapted for multibit parallel input and output configuration and for increasing the capacity.

**2. Description of the Prior Art**

In semiconductor memory circuits, the folded bit line structure in which a bit line for giving a reference potential to a sense amplifier (referred to as bit line for reference potential, hereinafter) and a bit line for reading out data of a memory cell (referred to as bit line for read, hereinafter) are arranged on one side of the sense amplifier, gives less induced noise to the bit line compared with the open bit line structure in which the bit line for reference potential and the bit line for read are arranged on the mutually opposite sides of the sense amplifier, so that it is currently in widespread use for semiconductor memory circuits.

Moreover, since in a semiconductor memory circuit such as a dynamic RAM (referred to as DRAM hereinafter) the ratio of the capacity of the memory cell capacitor (referred to as capacity of memory capacitor hereinafter) to the parasitic capacity of the bit line (referred to as capacity of bit line hereinafter) is related directly to the read voltage generated in the bit line, this ratio is an important parameter for the design of DRAM. The capacity of bit line is determined by the number, the size, and the structure of memory cells connected to the bit line, and the structure, size, material, or the like of the bit line itself. Accompanying the advancement of the generation of semiconductor memory circuits and the increase of the memory capacity, geometrical refinement of the memory cell and the bit line is advanced and the capacity of bit line is decreased. On the other hand, it brings about a decrease of the capacity of memory capacitor and an increase of the induced noise, and the number of the memory cells connected to one bit line has not been changed since it was increased from 64 bits to 128 bits for 256 kbit DRAM, even for the advances of the memory capacity of 1M bits, 4M bits, and 16M bits. Various kinds of split bit line modes have been proposed in order to keep the number of memory cells connected to one bit line constant, in the midst of the alternation of generation of DRAM as mentioned above, under the condition of limited chip size. Among them, the multisplit bit line shared sense amplifier mode (referred to as shared sense amplifier mode hereinafter) is being adopted most widely for the reasons that it is possible to realize a reduction of power consumption and an improvement of operating speed, and is most advantageous from the viewpoint of chip size (see for example, 16Mbit DRAM  $\mu$ PD4216400 made by NEC Corporation which is the assigned of this application).

Next, an example of semiconductor memory circuit of the shared sense amplifier mode will be described.

This semiconductor memory circuit comprises a plurality of memory cell arrays each including a plurality of memory cell trains connected respectively to bit line pairs of folded bit line mode, and are arranged in the direction in which each of these memory cell train extends while keeping the mutual correspondence relation among these memory cell trains, a plurality of first

This application is a  
reissue 08/084,017 filed  
6/30/93, now US Patent  
5,444,305.

selection/sense amplifier circuits each including first selection means which is arranged in every interarray regions between the pair of mutually adjacent memory cell arrays and selects for each member of the respective pairs either of an odd-numbered train or an even-numbered train of the plurality of memory cell trains of the memory cell arrays on both sides of the interarray region, a plurality of sense amplifiers which amplify the respective read data of the memory cell trains selected by the first selection means in one-to-one basis, and second selection means which selects one of the plurality of sense amplifiers and one of the memory cell trains selected by the first selection means and connect them to the corresponding data input and output lines, and transmits one of the amplified read data of an odd-numbered or an even-numbered memory cell train of the selected memory cell array on one side to the corresponding data input and output lines and supplies write data transmitted to the corresponding data input and output lines to a selected memory cell train of a selected memory cell array, two units of second selection/sense amplifier circuits each including a plurality of sense amplifiers arranged on the outside of the respective memory cell arrays at both ends of the disposition of the plurality of memory cell arrays and amplify in one-to-one basis read data of memory cell trains set differently from those of the first selection/sense amplifier circuits corresponding to the outermost memory cell arrays and selection means which selects one of the plurality of the sense amplifiers and one of the set memory cell trains of the outermost memory cell array and connects them to corresponding data input and output lines, and transmit amplified read data from the set memory cell trains of the outermost memory cell arrays to corresponding data input and output lines and supply write data transmitted to the corresponding data input and output lines to selected memory cell trains of the outermost memory cell arrays, a plurality of data buses corresponding to the respective bits of data which is transferred in bit parallel mode between an external circuit, and a plurality of input and output switching circuits which transmit the respective read data from the memory cell arrays one by one to the corresponding data buses via the first and the second selection/sense amplifier circuits by sequentially assigning equal number of memory cell arrays in the order of arrangement to the plurality of data buses, respectively, and supply write data transmitted to these data buses from the external circuit to respective selected memory cell trains of the corresponding memory cell arrays.

If it is assumed in this semiconductor memory circuit that, for example, the number of the memory cell arrays is eight, the number of the data buses is four, and the data transfer between the external circuit is carried out in four bit parallel mode, then seven first selection/sense amplifier circuits are arranged among eight memory cell arrays, a second selection/sense amplifier circuit is arranged on the outside of the each of the outermost memory cell array of the eight memory cell arrays, and a plurality of input and output switching circuits are arranged between the first and second selection/sense amplifier circuits and four data buses. Since two memory cell arrays each are made to correspond sequentially in the order of arrangement to the respective members of the four data buses, the first and the second memory cell arrays from the left correspond to the first data bus, the third and the fourth memory cell arrays

correspond to the second data bus, the fifth and the sixth memory cell arrays correspond to the third data bus, and the seventh and the eighth memory cell arrays correspond to the fourth data bus. Further, if the first and the second selection/sense amplifier circuits are designated from the left as the first, the second, . . . , and the ninth sense amplifiers, the data transmission between the first and the second memory cell arrays and the first data bus is executed via the first, second, and the third selection/sense amplifier circuits, the data transmission between the third and the fourth memory cell arrays and the second data bus is executed via the third, the fourth, and the fifth selection/sense amplifier circuits, and similarly, the data transmission between the fifth and the sixth memory cell arrays and the third data bus is executed via the fifth, the sixth, and the seventh selection/sense amplifier circuits, and the data transmission between the seventh and the eighth memory cell arrays and the fourth data bus is executed via the seventh, the eighth and the ninth selection/sense amplifier circuits.

As in the above, in this semiconductor memory circuit, the third, the fifth, and the seventh selection/sense amplifier circuits have to carry out the data transfer between the respective two data buses. For this reason, it becomes necessary to have two input and output switching circuits between these selection/sense amplifier circuits and the data buses, and the layout becomes complicated and the chip area needs be increased accordingly.

#### BRIEF SUMMARY OF THE INVENTION

#### OBJECT OF THE INVENTION

It is therefore the object of this invention to provide a semiconductor memory circuit which enables one to simplify the layout and reduce the chip area.

#### SUMMARY OF THE INVENTION

The semiconductor memory circuit according to this invention comprises a plurality of memory cell arrays each including a plurality of memory cell trains, arranged adjacent with each other in a predetermined direction, a plurality of first selection/sense amplifier circuits arranged in every region between mutually adjacent pair of memory cell arrays, which amplify read data from memory cell trains alternately designated in the order of arrangement out of odd-numbered and even-numbered trains on one selected side of memory cell arrays on both sides of the region between the cell arrays, transmit one of the data to corresponding data input and output lines and supply write data transmitted to the corresponding input and output lines to selected memory cell train of selected memory cell array, two units of second selection/sense amplifier circuits arranged on the outside of the respective memory cell arrays on both ends of the plurality of memory cell arrays, which amplify read data from predetermined one memory cell train of odd-numbered and even-numbered trains of the outermost memory cell arrays and transmit one of the data to the corresponding data input and output lines and supply write data transmitted to the corresponding input and output lines to a selected memory cell train of the outermost memory cell array, a plurality of data buses corresponding to the respective bits of data transferred in bit parallel mode between the external circuit, and a plurality of input and output switching circuits arranged and connected respectively in one-to-one correspondence to the first and the second

selection/sense amplifier circuits and connected to the plurality of the data buses so as to have equal number of memory cell trains that can carry out data transfer with the respective data buses, and carry out data transfer between these data buses and the first and the second selection/sense amplifier circuits in one-to-one correspondence mode.

In this semiconductor memory circuit, the input and output switching circuits are arranged in one-to-one correspondence to the first and the second selection/sense amplifier circuits, so that it is possible to simplify the layout and to decrease the chip area in proportion to the reduction in the number of input and output switching circuits.

#### BR<sup>E</sup> BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other objects, features and advantages of this invention will become more apparent by reference to the following detailed description of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a block diagram for an embodiment of the invention;

FIG. 2 is a circuit diagram for the memory cell arrays and first selection/sense amplifier circuits which constitute a part of the embodiment;

FIG. 3 is a block diagram for a modification of the embodiment; and

FIG. 4 is a block diagram for another modification of the embodiment.

#### DE<sup>E</sup> DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, the semiconductor memory circuit which is an embodiment of the invention shown in this figure comprises a plurality of memory cell arrays MCA1 to MCA8 each including a plurality of memory cell trains, arranged in the direction of extension of these memory cell trains while keeping the correspondence relation among these memory cell trains, a plurality of first selection/sense amplifier circuits SSA11 to SSA17, each circuit including, first selection means arranged in the region between the cell arrays, namely, between memory cell arrays MCA1 and MCA2, between MCA2 and MCA3, between MCA3 and MCA4, . . . , and between MCA7 and MCA8, respectively, and selects out of the memory cell trains of the memory cell arrays on both sides of every region between the cell arrays either an odd-numbered train or an even-numbered train designated alternately in the order of arrangement, one side at a time, a plurality of sense amplifiers which amplify read data of memory cell trains selected by the first selection means in one-to-one correspondence, and second selection means which selects one of the sense amplifiers and one of the memory cell trains selected by the first selection means and connects them to corresponding data input and output lines, and transmit one of amplified read data of an odd-numbered or an even-numbered memory cell train of memory cell array on one side (MCA1, for example) to the corresponding data input and output lines, and supply write data transmitted to the corresponding data input and output lines to a selected memory cell train of a selected memory cell array (MCA1, for example), second selection/sense amplifier circuits SSA21 and SSA22 which include a plurality of sense amplifiers, different from the selection/sense amplifier circuits

SSA11 and SSA17, arranged in cell end regions outside of the memory cell arrays MCA1 and MCA8 and respectively amplify in one-to-one correspondence the read data of memory cell arrays and selection means which selects one of these sense amplifiers and one of designated odd-numbered or even-numbered memory cell trains and connect them to corresponding data input and output lines, and transmit amplified read data from designated odd-numbered or even-numbered memory cell train of the memory cell arrays MCA1 and MCA8 to corresponding data input and output lines and supply write data transmitted to the corresponding data input and output lines to selected memory cell trains of memory cell arrays MCA1 and MCA8, a plurality of data buses DB11/DB12 to DB41/DB42 which correspond to data  $D_1$  to  $D_4$ , respectively, that are transferred in bit parallel manner between an external circuit, a plurality of input and output switching circuits IOS1 to IOS9 which are arranged in one-to-one correspondence to the first and the second selection/sense amplifier circuits SSA11 to SSA17/SSA21 and SSA22 and carry out one-to-one transfer of read data and write data between each of the data buses DB11/DB12 to DB41/DB42 and one of the corresponding selection/sense amplifier circuits by connecting the first input and output terminals to the data input and output lines of the corresponding selection/sense amplifier circuits and the second input and output terminals to one of the data buses DB11/DB12 to DB41/DB42 so as to have the number of memory cell trains capable of carrying out data transfer with the data buses is mutually equal, and data input and output circuits DIO1 to DIO4 which output read data transmitted to the data buses DB11/DB12 to DB41/DB42 to the external circuit in bit parallel manner and transmit write data from the external circuit to the data buses DB11/DB12 to DB41/DB42 in bit parallel manner.

Referring to FIG. 2 showing a part of the embodiment in terms of a specific circuit diagram, it can be seen that this embodiment has the folded bit line structure in which a bit line (BL12, for example) that gives a reference potential to the sense amplifier (SA11, for example) and a bit line for data read (BL11, for example) are arranged mutually parallel on one side of a sense amplifier (SA11).

An odd-numbered or an even-numbered memory cell train of the memory cell array is formed by memory cells (MCs) that are connected to a pair of bit lines for reference potential and for data read. For example, in the memory cell array MCA1, the memory cell train corresponding to the bit line pairs BL11/BL12 and BL15/BL16 forms an odd-numbered train, while the memory cell train corresponding to BL13/BL14 and BL17/BL18 forms an even-numbered train.

A first selection/sense amplifier circuit (SSA11, for example) has sense amplifiers (SA11, SA12, ...) provided one each for the memory cell train corresponding to one (odd-numbered train in SSA11) of odd-numbered and even-numbered trains of memory cell arrays on its both sides (MCA1 and MCA2, for example), data transfer circuits (DT11 and DT12) of the first selection means which selects, one side at a time, an odd-numbered or an even-numbered memory cell train of the memory cell arrays (MCA1 and MCA2) on both sides in response to transfer control signals (TG<sub>11</sub> and TG<sub>12</sub>) and connects it to the corresponding sense amplifier circuit, and a train selection circuit (VS1) of the second selection means which connects one of odd-numbered

or even-numbered memory cell train of the memory cell array selected by the data transfer circuits (DT11 and DT12) and one of the sense amplifier circuits selected in response to train selection signals ( $Y_{11}$ ,  $Y_{12}$ ) to data input and output lines (IO11 and IO12).

Further, since the second selection/sense amplifier circuits SSA21 and SSA22 merely make access to only one of odd-numbered and even-numbered trains of the memory cell trains of the memory cell arrays MCA1 and MCA2, each of them has one data transfer circuit (not shown in FIG. 2). The remaining construction is identical to the first selection/sense amplifier circuit. The access memory cell trains of the second selection/-sense amplifier circuits SSA21 and SSA22 are even-numbered trains since the access memory cell trains of the adjacent first selection/sense amplifier circuits SSA11 and SSA17 are odd-numbered trains.

As described in the above, the access memory cell trains of the first and the second selection/sense amplifier circuits SSA11 to SSA17/SSA21 and SSA22 are so fixed as to be alternately an odd-numbered and an even-numbered train according to the order of their arrangement, there is obtained a semiconductor memory circuit of the shared sense amplifier mode.

In this embodiment, the memory cell trains that can transfer data between the data buses DB11/DB12 via the selection/sense amplifier circuits SSA11 to SSA17/-SSA21 and SSA22 and the input and output switching circuits IOS1 to IOS9 are both the odd-numbered and even-numbered trains of the memory cell array MCA1, odd-numbered trains of the memory cell array MCA2, and even-numbered trains of the memory cell array MCA8, and the memory cell trains that can transfer data between the data buses DB21/DB22 are even-numbered trains of the memory cell array MCA2, both the odd-numbered and even-numbered trains of the memory cell array MCA3, and odd-numbered trains of the memory cell array MCA4. Similarly, for the data buses DB31/DB32, they are even-numbered trains of MCA4, both the odd-numbered and even-numbered trains of MCA5, and odd-numbered trains of MCA6, and for the data buses DB41/DB42, they are even-numbered trains of MCA6, both the odd-numbered and even-numbered trains of MCA7, and odd-numbered trains of MCA8. One each of the memory cell trains that can carry out data transfer between each of the data buses DB11/DB12 to DB41/DB42 is selected by the selection/sense amplifier circuits SSA11 to SSA17/-SSA21 and SSA22, and read for an external circuit of four-bit data  $D_1$  to  $D_4$  and write from the external circuit is carried out in bit parallel via the data input and output circuits DIO1 to DIO4.

In the conventional semiconductor memory circuit, the memory cell arrays that can transfer data between the data bus DB11/DB12 are MCA1 and MCA2, and similarly, for the data bus DB21/DB22 they are MCA3 and MCA4, for the data bus DB31/DB32 they are MCA5 and MCA6, and for the data bus DB41/DB42 they are MCA7 and MCA8. Accordingly, the selection/sense amplifier circuit SSA12 situated between the memory cell arrays MCA2 and MCA3 needs to perform data transfer with the two data buses DB11/DB12 and DB21/DB22, the selection/sense amplifier circuit SSA14 between the memory cell arrays MCA4 and MCA5 needs to perform data transfer with the two data buses DB21/DB22 and DB31/DB32, and the selection/sense amplifier circuit SSA16 between the memory cell arrays MCA6 and MCA7 needs to perform data

transfer with the two data buses DB31/DB32 and DB41/DB42. Therefore, input and output circuits of two each are required between the selection/sense amplifier circuit SSA12, SSA14, SSA16 and the data buses DB11/DB12 to DB41/DB42, and it results in complication of the layout and increase of the chip area in proportion to this situation.

In contrast, in this invention one data bus is assigned to each of the selection/sense amplifier circuits SSA11 to SSA17/SSA21 and SSA22, so that the input and output switching circuit between each of these selection/sense amplifier circuits SSA11 to SSA17/SSA21 and SSA22 and the data buses DB11/DB12 to DB41/DB42 becomes one for each, and accordingly it is possible to simplify the layout and reduce the chip area.

Referring to FIG. 3 showing a modification of the embodiment, even-numbered trains (or odd-numbered trains) of the memory cell trains are made to correspond to odd-numbered data buses. The correspondence relation between the even-numbered train/odd-numbered train and the data buses can be anything provided that the number of the memory cell trains connectable to each data bus is equal.

Furthermore, the second selection/sense amplifier circuits SSA21 and SSA22 have memory cell trains of one of odd-numbered and even-numbered trains of the outermostly arranged memory cell arrays (MCA1 and MCA8) as the objects of access. Therefore, if the number of memory cell arrays connectable to one data bus is taken as the memory cell array unit (namely, the memory cell trains for an integral number of memory cell arrays), the second selection/sense amplifier circuits are connected without fail to the identical data bus via the corresponding input and output switching circuits. Accordingly, if the number of memory cell trains connectable to one data bus is set to be equal to an even number of times of the memory cell arrays, then the input and output switching circuit arranged at the center can also be made to be surely connected to the identical data bus for the outermost input and output switching circuits. Consequently, the pattern of the connection lines between the input and output switching circuits and the data buses can be made laterally symmetric with respect to the input and output switching circuit at the center, and the array design can further be facilitated. An example of the laterally symmetric pattern of the connection lines is shown in FIG. 4. There can be thought several patterns of laterally symmetric connection lines other than the one shown in FIG. 4, but a simple pattern with maximum regularity is advantageous.

Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as other embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. It is therefore contemplated that appended claims will cover any modifications or embodiments as fall within the true scope of the invention.

What is claimed is:

1. A semiconductor memory circuit comprising:  
a plurality of memory cell arrays each consisting of a plurality of memory cell trains arranged in a direction in which these memory cell trains extend while keeping the mutual corresponding relationship among the memory cell trains;